INSTITUTE FOR PHYSICAL RESEARCH AND TECHNOLOGY

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SPACE LIFE SUPPORT ENGINEERING PROGRAM

SEMIANNUAL PROGRESS REPORT
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SUBMITTED TO DR. EDWIN L. FORCE
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PROGRESS REPORT

Space Life Support Engineering Program
Iowa State University
Ames. Iowa

Period: July 1. 1991 through December 31. 1991

Summary

This report covers the first six months of work performed under the NASA University Grant awarded to Iowa State University to perform research on two topics relating to the development of closed-loop long-term life support systems.

I. Water Management in Long-Term Closed-Loop Life Support Systems

Overview

A comprehensive study to develop software to simulate the dynamic operation of water reclamation systems in long-term closed-loop life support systems is being carried out as part of an overall program for the design of systems for a Mars voyage. This project is being done in parallel with a similar effort in the Department of Chemistry to develop durable accurate low-cost sensors for monitoring of trace chemical and biological species in recycled water supplies. Aspen-Plus software is being used on a group of high-performance work stations to develop the steady state descriptions for a number of existing technologies. Following completion. a dynamic simulation package will be developed for determining the response of such systems to changes in the metabolic needs of the crew and to upsets in system hardware performance.

Personnel: Director: R. C. Seagrave. Distinguished Professor of Chemical Engineering
Post Doctoral Research Fellow: Michael K. Dowd (through October 31. 1991
Graduate Research Assistant: Dasaratha Sridhar (began October 1. 1991)
Graduate Research Assistant: Sharmista Chatterjee (entire period)
Undergraduate NASA Fellow: Carolyn Pals (through December 15. 1991)
Undergraduate Research Assistants: Amy Weber. Chris Olson

Research Summary

During the first six months the following developments have occurred and tasks have been accomplished:

1. Two DEC 2100 workstations and a DEC 3100 color workstation have been configured and supplied with Aspen Plus software. These stations are dedicated to the project.

2. A technical exchange agreement has been executed with Aspen Technology. under which the group at Iowa State and Aspen Plus engineers in Cambridge will exchange visits to assist in the software development for the dynamic modeling programs.

3. Access to the interactive life support system data base at the Ames Research Center has been completed. and it has been made available on all three work-stations.

4. Aspen sub-programs are being developed for the steady-state operation simulation for a closed-loop life support system. The work has been developed as follows:

Water treatment systems: Sharmista Chatterjee (a second year graduate student working on a Ph. D. program)

1. Urine purification
2. Wash water processing
3. Gray water processing
4. Electroincineration of wastes
5. SolidWaste water removal

Air regeneration systems. oxygen generation systems: Carolyn Pals (a last semester senior in chemical engineering and the recipient of a NASA Space Grant consortium summer fellowship and senior scholarship. and Dasaratha Sridhar. (a first-year graduate student in chemical engineering).

1. CO_2 removal
2. CO_2 reduction
3. Oxygen generation
4. Air conditioning
5. Trace contaminant removal

Crew model: Chris Olson (a senior in Aerospace Engineering)

1. Inputs: Height. Weight. Age. Gender. Fitness level. Activity
2. Outputs: Oxygen consumption. CO_2 production. water evaporation. heat production. food consumption. water consumption

Plant Model: Amy Weber (a senior in Chemical Engineering)

1. Inputs: Energy. CO_2. waste products
2. Outputs: Oxygen. water. biomass production

As a basis for beginning. technology designed for Space Station Freedom is being used as the baseline system. Each person is simultaneously investigating alternate technology simulation. and a dynamic model has been developed for the crew. This will be used as a "forcing function" to generate a series of steady-state solutions for the integrated system running under Aspen Plus in a series of interrelated steady states. This baseline set of calculations will serve as the foundation for the dynamic system development.

5. Integration of the individually developed Aspen blocks and Fortran-based models has begun. Dynamic models for the crew members are being developed by modifying an earlier-developed model for predicting the recommended duration of exercise as a function of environmental conditions.

6. The 24 member senior level design class in the chemical engineering department used the long-term closed-loop problem as a senior design class problem. working under the direction of Professors Dean Ulrichson and R. C. Seagrave. This activity has assisted

the group in working through alternate set of scenarios. The design class used a group of 15 DECstation 3100 color workstations for their investigations.

7. In a parallel effort, Seagrave and Dowd are performing a thermodynamic analysis of the closed-loop system in order to identify quantities such as the maximum efficiency, the minimum energy cost, the optimal operating conditions, and the minimum entropy production associated with a life-supported mission. These quantities, expressed as functions of the crew needs and operating parameters such as temperature and pressure, will serve as guideposts in the simulations. Also, this approach should suggest some new criteria for evaluating the relative merits of alternate technologies for the various functions of the system.

8. A dynamic modelling software package (EXTEND, Imagine That, Inc., San Jose, CA) has been obtained and implemented on our machines. It is being used to test preliminary transient models before they are moved to the UNIX-based workstations to make them compatible with the ASPEN-PLUS models. Along with the conversion of the VAX-based dynamic crew model, this now makes a total of three platforms and operating systems that we are integrating, with the goal of reducing this to one flexible system.

9. On October 29, R. C. Seagrave presented a discussion at the Allied-Signal Research Laboratories in Des Plaines, Illinois, on 'Chemical Engineering Problems in Closed-Loop Life Support Systems", and discussed possible collaboration with personnel from the Allied Signal Aerospace Corporation in Torrance, CA.

10. On November 19, R. C. Seagrave visited the group of Dr. P. K. Seshan at the Jet Propulsion Laboratory in Pasadena, CA to discuss aspects of the simulations and future collaboration. One result of this is a modification of the dynamic crew model to include environmental effects on the rate of urine production, which Chris Olson is now implementing.

Scheduled Work for 1/192 to 6/30/92

For the next six months the following goals have been identified:

1. Integrate the dynamic crew model with the steady-state life support system model.

2. Using the dynamic software package, develop a first approximation to the dynamic life support behavior. Use that to gain insight into the levels of approximation that are appropriate to begin "dynamicizing" the steady-state model.

3. Continue with the "Exergy" analysis to develop criteria for categorizing the various technology choices for air and water treatment.